

FORM PTO-1390 (Modified)
(REV 11-98)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

ATTORNEY'S DOCKET NUMBER

TRANSMITTAL LETTER TO THE UNITED STATES

L7307.01106

DESIGNATED/ELECTED OFFICE (DO/EO/US)

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR

CONCERNING A FILING UNDER 35 U.S.C. 371

New Application 09/806343

INTERNATIONAL APPLICATION NO.
PCT/FR99/02400INTERNATIONAL FILING DATE
October 7, 1999PRIORITY DATE CLAIMED
October 8, 1998

TITLE OF INVENTION

ELECTROMAGNETIC PULSE TRAIN GENERATION FOR TESTING OPTICAL FIBRES

APPLICANT(S) FOR DO/EO/US

Bruno DUCHENNE and Jacques ISBERT

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☐ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
 - a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau).
 - b. ☐ has been transmitted by the International Bureau.
 - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ A copy of the International Search Report (PCT/ISA/210).
8. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
 - a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
 - b. ☐ have been transmitted by the International Bureau.
 - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
 - d. ☐ have not been made and will not be made.
9. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
10. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
11. ☐ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

Items 13 to 20 below concern document(s) or information included:

13. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☒ A **FIRST** preliminary amendment.
16. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
17. ☐ A substitute specification.
18. ☐ A change of power of attorney and/or address letter.
19. ☐ Certificate of Mailing by Express Mail
20. ☒ Other items or information:

Verification of a Translation
 Claim for Priority with PCT/IB/304
 PCT/RO/101
 PCT/IPEA/416

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR

New Application
09/806343

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21. The following fees are submitted:

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :

- ☐ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO \$1,000.00
- ☒ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO \$860.00
- ☐ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO \$710.00
- ☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) \$690.00
- ☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) \$100.00

ENTER APPROPRIATE BASIC FEE AMOUNT =

\$860.00

Surcharge of \$130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).

\$0.00

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE
Total claims	10 - 20 =	0	x \$18.00
Independent claims	1 - 3 =	0	x \$80.00

\$0.00

\$0.00

Multiple Dependent Claims (check if applicable). ☐

\$0.00

TOTAL OF ABOVE CALCULATIONS =

\$860.00

Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28) (check if applicable). ☐

\$0.00

SUBTOTAL =

\$860.00

Processing fee of \$130.00 for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (f)).

\$0.00

TOTAL NATIONAL FEE =

\$860.00

Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) (check if applicable). ☒

\$40.00

TOTAL FEES ENCLOSED =

\$900.00

Amount to be:
refunded

\$

charged

\$

☒ A check in the amount of \$900.00 to cover the above fees is enclosed.☐ Please charge my Deposit Account No. _____ in the amount of _____ to cover the above fees.
A duplicate copy of this sheet is enclosed.☒ The Commissioner is hereby authorized to charge any fees which may be required, or credit any overpayment to Deposit Account No. 19-4375 A duplicate copy of this sheet is enclosed.**NOTE:** Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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SIGNATURE

James E. Ledbetter

NAME

28,732

REGISTRATION NUMBER

March 29, 2001

DATE

09/806343

JCOB Rec'd CT/PTO 29 MAR 2001

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of

Inventors: Bruno DUCHENNE et al.

Application No.: New Patent Application

Filed: March 29, 2001

For: ELECTROMAGNETIC PULSE TRAIN GENERATION FOR
TESTING OPTICAL FIBRES

PRELIMINARY AMENDMENT

Honorable Commissioner of
Patents and Trademarks
Washington, DC 20231

Sir:

Please amend the above application as follows:

IN THE CLAIMS

Please amend the claims as follows (Exhibit I is a marked-up
version of the claims):

6. (Amended) The emitter as claimed in claim 1,
characterized in that it comprises means (16) preventing an
electromagnetic pulse generated by said generator (2) from
returning toward the latter.

7. (Amended) The emitter as claimed in claim 1,
characterized in that said generator (2) is capable of generating
at least two pulses, of different wavelengths.

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8. (Amended) A test system for determining the losses of a fiber-optic component, said system comprising:

an optical source (1D) capable of emitting at least one electromagnetic pulse;

a photoreceiver (20) capable of measuring characteristics of an electromagnetic pulse emitted by said optical source (1D) and transmitted by a fiber-optic component (19, 21); and

data acquisition, storage and processing means (22, 24) which receive the measurements generated by said photoreceiver (20) for said fiber-optic component (19) to be tested and for a reference fiber-optic component (21) and which determine, on the basis of these measurements, the losses of said fiber-optic component (19) to be tested, characterized in that said optical source comprises the emitter (1D) specified under claim 1.

10. (Amended) The use of the emitter specified under claim 1, in order to determine the value of at least one characteristic parameter of a fiber-optic component, in which use:

a) at least one electromagnetic pulse is generated, which is emitted into said fiber-optic component (19);

b) measurements relating to said electromagnetic pulse transmitted by said fiber-optic component (19) are carried out; and

c) said characteristic parameter is determined at least from said measurements, characterized in that, in step a), an electromagnetic pulse train is generated by means of said emitter, at least some of the electromagnetic pulses of which have different values for at least one optical characteristic, and in that, in step c), the value of said characteristic parameter is determined for each of said different electromagnetic pulses of said pulse train.

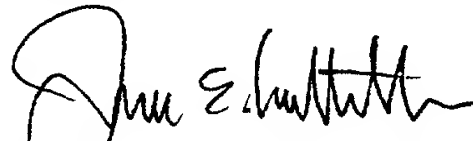
090303-0304

REMARKS

This Preliminary Amendment eliminates the multiple dependent claim status of claims 6, 7, 8 and 10 in order to avoid the multiple dependent claim surcharge.

Early and favorable consideration of this application is respectfully requested.

Respectfully submitted,



James E. Ledbetter
Registration No. 28,732

Date: March 29, 2001

JEL/clw

ATTORNEY DOCKET NO. L7307.01106

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EXHIBIT I - MARKED UP VERSION OF CLAIMS

6. (Amended) The emitter as claimed in [any one of the preceding claims] claim 1, characterized in that it comprises means (16) preventing an electromagnetic pulse generated by said generator (2) from returning toward the latter.

7. (Amended) The emitter as claimed in [any one of the preceding claims] claim 1, characterized in that said generator (2) is capable of generating at least two pulses, of different wavelengths.

8. (Amended) A test system for determining the losses of a fiber-optic component, said system comprising:

an optical source (1D) capable of emitting at least one electromagnetic pulse;

a photoreceiver (20) capable of measuring characteristics of an electromagnetic pulse emitted by said optical source (1D) and transmitted by a fiber-optic component (19, 21); and

data acquisition, storage and processing means (22, 24) which receive the measurements generated by said photoreceiver (20) for said fiber-optic component (19) to be tested and for a

reference fiber-optic component (21) and which determine, on the basis of these measurements, the losses of said fiber-optic component (19) to be tested, characterized in that said optical source comprises the emitter (1D) specified under [any one of claims 1 to 7] claim 1.

10. (Amended) The use of the emitter specified under [any one of claims 1 to 7] claim 1, in order to determine the value of at least one characteristic parameter of a fiber-optic component, in which use:

a) at least one electromagnetic pulse is generated, which is emitted into said fiber-optic component (19);

b) measurements relating to said electromagnetic pulse transmitted by said fiber-optic component (19) are carried out; and

c) said characteristic parameter is determined at least from said measurements, characterized in that, in step a), an electromagnetic pulse train is generated by means of said emitter, at least some of the electromagnetic pulses of which have different values for at least one optical characteristic, and in that, in step c), the

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JCO3 Rec'd PCT/PTO 29 MAR 2001
PCT/FR99/02400

WO 00/22402

**GENERATION OF AN ELECTROMAGNETIC PULSE TRAIN FOR
TESTING OPTICAL FIBERS**

5 The present invention relates to an emitter for emitting electromagnetic pulses, to a system for testing fiber-optic components and to a method of testing them.

Said emitter, of the type comprising:

- 10 - a generator for generating at least one electromagnetic pulse, especially a light pulse; and
- at least one optical fiber capable of transmitting an electromagnetic pulse generated by said
- 15 generator for the purpose of injecting it,
- is able to be applied more particularly, although not exclusively, to a test system for determining characteristic parameters, especially the losses, of a fiber-optic component, in particular a fiber-based
- 20 component, a fiber-based link or a fiber-optic network.

Patent US-5 251 002 discloses such a test system, which comprises:

- such an optical emitter or source capable of emitting a light pulse;
- 25 - a photoreceiver capable of measuring optical characteristics of a light pulse emitted by said optical source and transmitted by a fiber-optic component; and
- data acquisition, storage and processing means
- 30 which receive the measurements generated by said photoreceiver for said fiber-optic component to be tested and for a reference fiber-optic component and which determine, on the basis of these measurements, the losses of said fiber-optic
- 35 component to be tested.

In a known manner, said optical source or said emitter has emission conditions, especially with regard

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characteristics (emission solid angle and emission area) which are variable.

For this purpose, according to the invention, said emitter for emitting electromagnetic pulses, comprising:

- a generator for generating at least one electromagnetic pulse; and
- at least one optical fiber capable of transmitting an electromagnetic pulse generated by said generator for the purpose of emitting it,

is noteworthy in that it includes in addition at least one optical cavity:

- which is placed in the path of an incident electromagnetic pulse transmitted by said optical fiber; and
- which has an input provided with a first partially reflecting mirror and an output provided with a second partially reflecting mirror, said first and second mirrors being arranged so as to create at the output of said optical cavity, from a single incident electromagnetic pulse, a train of emitted electromagnetic pulses which have variable geometry characteristics and are associated with said incident electromagnetic pulse.

Thus, by virtue of said optical cavity, the emitted pulse train comprises pulses subjected to variable numbers of reflections off said mirrors and therefore traveling variable distances in said cavity. However, since the aforementioned geometry characteristics vary, in a known manner, according to the distance traveled, the various pulses of said pulse train have variable geometry characteristics (emission solid angle and emission area).

Consequently, by choosing appropriate characteristics of said optical cavity, and especially the reflection/transmission ratio of the partially reflecting mirrors and the distance between them, a plurality of pulses having predetermined emission characteristics can be formed.

In particular, when said emitter is applied to a test system of the aforementioned type, it is possible to form a particular pulse train comprising the various possible configurations of the light beams likely to be transmitted by the component to be tested.

This enables the aforementioned drawbacks of the known test system, described in particular in patent US-5 251 002, to be remedied since it is no longer necessary to provide a plurality of different optical sources in order to carry out an overall test.

Moreover, advantageously, at least one of said first and second mirrors is linked to two lengths of the optical fiber:

- in a first embodiment, directly by opposed faces; and
- in a second embodiment, via an associated optical coupling means.

In this second embodiment, said or each of said optical coupling means advantageously comprises:

- in a first embodiment, two lenses optically linking said two lengths of the optical fiber, the mirror associated with said optical coupling means being placed between said lenses;
- in a second embodiment, a single half-wave graded-index lens, said mirror being placed on that face of said optical coupling means which is internal to said optical cavity; and
- in a third embodiment, two quarter-wave graded-index lenses optically linking said two lengths of the optical fiber, the mirror associated with said optical coupling means being placed between said lenses.

Moreover, the emitter according to the invention advantageously comprises means preventing a pulse generated by said generator from returning toward the latter. For this purpose, said means preferably include at least one light trap which cooperates with the optical coupling means associated with said first mirror.

Furthermore, said generator is advantageously capable of generating at least two pulses, of different wavelengths, thereby making it possible in particular, when applying it to a test system, to measure
5 simultaneously the losses at several operating wavelengths of certain types of links such as, for example, video communication links operating at wavelengths of 0.85 μm and 1.3 μm .

The present invention also relates to a test
10 system of the aforementioned type.

According to the invention, said test system is noteworthy in that the optical source of this system comprises a light-pulse emitter, as mentioned above.

In addition to the advantages indicated above,
15 this test system according to the invention has an operating life (or lifetime) longer than that described in patent US-5 251 002. This is because this known latter system, which includes electrooptic switches, only allows a relatively small number of uses and, in
20 addition, it is sensitive to the environmental conditions, something which is not the case in the system according to the invention, which has no mechanical moving parts.

It should also be noted that the optical fiber
25 of the pulse emitter generally has characteristics (core diameter and numerical aperture) identical to those of the fiber-optic component to be tested. This makes it possible to vary over time, in the same direction, the emission area and the emission solid
30 angle, these latter two geometry characteristics decreasing for each successive pulse.

However, in one particular embodiment, the electromagnetic pulse emitter is formed in such a way that one of said geometry characteristics is constant
35 and the other varies.

For this purpose, according to the invention:

- in order to obtain a constant emission solid angle, an optical fiber is provided which has the same core diameter as the core diameter of the

fiber-optic component to be tested, but with a larger numerical aperture; and

- in order to obtain a constant emission area, an optical fiber is provided which has the same numerical aperture, but a larger core diameter than the component to be tested.

Moreover, the present invention also relates to a test method for determining the value of at least one characteristic parameter, such as the attenuation of the electromagnetic intensity, of a fiber-optic component, which method makes it possible in particular to remedy the aforementioned drawbacks of the known method implemented by the test system described in patent US-5 251 002.

This known method, as indicated above, takes measurements for only a single type of pulse. Thus, when information is needed for a plurality of different pulses, it is necessary to use said known method for each of said pulses. In addition, to be able to adapt or compare the results then obtained, it is necessary to create the same operating conditions for each of these different tests. This is time-consuming, tedious and a source of errors.

In order to remedy these drawbacks, said method according to the invention for determining the value of at least one characteristic parameter of a fiber-optic component, in which method:

- a) at least one electromagnetic pulse is generated, which is injected into said fiber-optic component;
- b) measurements relating to said electromagnetic pulse transmitted by said fiber-optic component are carried out; and
- c) said characteristic parameter is determined at least from said measurements,

is noteworthy in that, in step a), an electromagnetic pulse train is generated, at least some of the electromagnetic pulses of which have different values for at least one optical characteristic, especially an emission geometry characteristic such as the emission

area or the emission solid angle, and in that, in step c), the value of said characteristic parameter is determined for each of said different electromagnetic pulses of said pulse train.

5 Thus, thanks to the invention, tests for a plurality of different pulses are carried out in a single implementation of the method. This has a number of advantages, and especially a reduction in the length and the cost of the tests when these have to be carried
10 out for a plurality of different pulses, and an increase in the accuracy, since it is no longer necessary to try to recreate identical operating conditions for a plurality of different tests.

Advantageously, in order to generate said pulse
15 train:
- a plurality of pulses is formed from one incident electromagnetic pulse; and
- said pulses are made to travel different distances in at least one optical fiber, said pulses forming
20 said pulse train at the exit of said optical fiber.

This is preferably carried out using the aforementioned emitter and in accordance with the invention.

25 In addition, said characteristic parameter advantageously represents the losses of said fiber-optic component and, in step b), measurements are carried out on said fiber-optic component and on a reference fiber-optic component.

30 The figures of the appended drawing will clearly explain how the invention can be realized. In these figures, identical references denote similar components.

Figure 1 shows an emitter according to the
35 invention.

Figures 2 to 4 show, schematically and non-exhaustively, three different embodiments of an emitter according to the invention, respectively.

Figure 5 shows, schematically, a test system according to the invention for testing a fiber-optic component.

5 The emitter 1A, 1B, 1C and 1D according to the invention, shown in Figures 1 to 4 respectively, is intended to emit electromagnetic pulses, in this case light pulses.

Said emitter 1A to 1D is of the type comprising:

- 10 - a generator 2, for example a light-emitting diode, a laser diode or a superluminescent diode, capable of generating a light pulse; and
- an optical fiber F linked to the generator 2 and capable of transmitting a light pulse generated by
- 15 said generator 2 for the purpose of emitting it.

The emission geometry characteristics of this generator 2 are, in a known manner, fixed and uniform with regard to the emission solid angle and the emission area.

- 20 According to the invention, in order to obtain variable geometry characteristics, said emitter 1A to 1D also includes an optical cavity 3A to 3D.

Each of said optical cavities 3A to 3D comprises:

- 25 - a first mirror, of the partially reflecting type, M1A, M1B, M1C and M1D respectively, which is placed between two lengths F1 and F2 of the optical fiber F, said length F1 being linked to the generator 2 in a known manner;
- 30 - a second mirror, M2A, M2B, M2C and M2D respectively, which may be of the same type as said first mirror and is placed between the length F2 and a length F3 of the optical fiber F; and
- said length F2 being used to link said first and
- 35 second mirrors together.

Thus, a light pulse which is generated by the generator 2 and enters the optical cavity 3A to 3D is partially transmitted by the mirror M2A to M2D and partially reflected by the latter, the reflected part

then also being partially reflected by the mirror M1A to M1D so as to return to said mirror M2A to M2D where it is again partially reflected and partially transmitted, and so on. This makes it possible to
5 produce at the output of the optical cavity 3A to 3D a train of temporally shifted pulses.

Each of said pulses in the length F2 has therefore traveled a path of different length.

Now, theory [S.D. Personick, Bell Syst. Tech.
10 J. 50, 843, (1971)], confirmed by experimentation, demonstrates that the conditions for propagation of a light wave in an optical fiber vary depending on the length of the fiber, in this case the length F2. This variation (temporal broadening of the injected pulse or
15 variation in the geometry, namely the core diameter and numerical aperture associated with the solid angle) is a variation depending on the length up to a fiber length defined as the modal equilibrium length, and above this the variation in the pulse broadening
20 depends on the square root of the length and the geometry is constant. This modal equilibrium state is reached when the light mixed in one mode is statistically compensated for by the light which leaks therefrom.

25 As a consequence, the various pulses of the pulse train emitted by the emitter 1A to 1D have variable emission geometry characteristics.

Thus, by suitably choosing the optical cavity 3A to 3D, especially with regard to the length of the
30 fiber length F2 and the transmission/reflection ratio of said first and second mirrors, it is possible to define precisely the geometry characteristics of the various pulses emitted and thus obtain, thanks to the invention, from a single pulse generated by the
35 generator 2, a train of variable and precisely defined pulses.

It will be noted that the generation by an optical cavity of length l , from an injected pulse, of a pulse train makes it possible to obtain, for the

output pulse of rank N , the propagation equivalent (modal dispersion, chromatic dispersion, change in geometry) in a fiber of length l ($2N-1$).

As an example, the emitter 1A to 1D according to the invention can be used to emit a pulse train generating some fifteen different emission characteristics, between the following limits:

- 70% to 100% of the numerical aperture of an illuminated optical fiber; and
- 10 - 70% to 100% of the core diameter of said illuminated optical fiber.

In the embodiment shown in Figure 1, the mirrors M1A and M2A each have a layer of partially reflecting material which is deposited directly on a length of the optical fiber F and the adjacent lengths are bonded together, whereas in the embodiments shown in Figures 2 to 4 the mirrors M1B, M2B, M1C, M2C, M1D and M2D are coupled, respectively, to optical coupling means C1B, C2B, C1C, C2C, C1D and C2D which are explained below.

As may be seen in Figure 2, the coupling means C1B and C2B each comprise two lenses 4, 5 and 6, 7, for example spherical or aspherical lenses, between which the corresponding mirror M1B, M2B is placed.

In addition, the lens 4 is linked to the length F1, the lenses 5 and 7 are linked to the length F2 and the lens 6 is linked to the length F3, in a known manner.

Furthermore, the optical coupling means C1C and C2C each comprise two lenses 8, 9 and 10, 11 of the quarter-wave graded-index type, these being linked to the lengths F1 to F3 of the optical fiber F and between which lenses the corresponding mirror M1C, M2C is placed, as shown in Figure 3.

As regards the optical coupling means C1D and C2D shown in Figure 4, these each comprise a lens 12, 13 of the half-wave graded-index type and the corresponding mirrors M1D and M2D are placed on those

faces 14 and 15 of said optical coupling means C1D and C2D which are internal to the optical cavity 3D.

In addition, said means C1D includes a light trap 16 intended to eliminate the light reflected by the mirror M1D and therefore to prevent a pulse emitted by the generator 2, or part of this pulse, from returning to the generator. Of course, such a light trap may be provided in the various possible embodiments.

Furthermore, it will be noted that, according to the invention:

- the techniques of alignment and of mounting the lengths of optical fiber and the coupling means may be of any known type;
- the deposition of the reflecting layers of the mirrors may be carried out either on both ends of the fiber F2 of the optical cavity, or on the coupling means;
- the length of the optical fiber F2 of the optical cavity may be chosen within a wide range of values. By way of example, this length may be 50 meters;
- the emitter 1A to 1D applies to any type of multimode optical fiber F, whatever its core diameter and cladding diameter, and whatever the material (silica, silicone, polymer) used to make it; and
- said emitter 1A to 1D has no mechanical moving parts, which are a source of failure.

It should also be noted that many applications of the aforementioned emitter 1A to 1D are possible, especially for taking measurements, and in particular for measuring various characteristic parameters such as:

- the attenuation of fiber-optic components or harnesses or of multimode fiber networks;
- the mode transfer function of fiber-optic components or harnesses;
- the error rate of a fiber-optic link; or

- the bandwidth of a multimode optical fiber.

For this purpose, the present invention also relates to a method for measuring such a characteristic parameter of a fiber-optic component, and especially
5 the losses in it.

More specifically, it relates to a method in which:

- a) at least one electromagnetic pulse, especially a light pulse, is generated, which is injected into
10 said fiber-optic component;
- b) measurements relating to said electromagnetic pulse transmitted by said fiber-optic component are carried out; and
- c) said characteristic parameter is determined at
15 least from said measurements.

According to the invention, in step a), an electromagnetic pulse train is generated, at least some of the electromagnetic pulses of which have different values for at least one optical characteristic,
20 especially an emission geometry characteristic, and, in step c), the value of said characteristic parameter is determined for each of said different electromagnetic pulses of said pulse train.

Figure 5 shows a test system 18 according to
25 the invention, which allows the aforementioned method to be implemented and which is intended to determine the losses of a fiber-optic component 19, for example a fiber component, a fiber link or a fiber-optic network.

For this purpose, said system 18 comprises,
30 according to the invention:

- a light pulse emitter as mentioned above, according to the invention and corresponding in this case, by way of example, to that of the embodiment 1D in Figure 4;
- 35 - a photoreceiver 20 of known type, for example a PIN photodiode or an APD photodiode, capable of measuring characteristics such as the intensity of a light pulse which is emitted by said emitter 1D

and which is transmitted by a fiber-optic component 19 or 21;

- means 22, for example a memory, linked by an electrical link 23 to the photoreceiver 20 and intended to record the measurements made by said photoreceiver 20; and
- means 24 linked via electrical links 25 and 26 to the generator 2 and to the means 22, respectively, and determining, from the measurements received and carried out by the photoreceiver 20, on the one hand for said component 19 to be tested and, on the other hand, for a reference component 21, for example a single optical fiber of short length, the losses of said component 19.

15 The results of the tests thus carried out may be displayed by means 27 linked via an electrical link 28 to said means 24.

20 In order to carry out the measurements, the components 19 and 21 may be linked to the length F3 and to a length F4 (joined to the photoreceiver 20) of the optical fiber, via known means E1, E2, acting together and forming, for example, a universal socket.

25 The length F3 and the component 19 have the same core diameter and the same numerical aperture. However, within the context of the present invention, one of these characteristics may also differ from one component to another, in order to obtain simultaneously a constant geometry characteristic (for example, the emission area) and a variable geometry characteristic
30 (for example, the emission solid angle).

CLAIMS

1. An emitter for emitting electromagnetic pulses,
5 comprising:
- a generator (2) for generating at least one electromagnetic pulse; and
 - at least one optical fiber (F) capable of transmitting an electromagnetic pulse generated by
10 said generator (2) for the purpose of emitting it, characterized in that it includes in addition at least one optical cavity (3A, 3B, 3C, 3D):
- which is placed in the path of an incident electromagnetic pulse transmitted by said optical
15 fiber (F); and
 - which has an input provided with a first partially reflecting mirror (M1A, M1B, M1C, M1D) and an output provided with a second partially reflecting mirror (M2A, M2B, M2C, M2D), said first and second
20 mirrors being arranged so as to create at the output of said optical cavity (3A, 3B, 3C, 3D), from a single incident electromagnetic pulse, a train of emitted electromagnetic pulses which have variable geometry characteristics and are
25 associated with said incident electromagnetic pulse.
2. The emitter as claimed in claim 1, characterized in that at least one of said first and second mirrors (M1A, M2A) is linked directly by opposed
30 faces to two lengths (F1, F2, F3) of said optical fiber (F).
3. The emitter as claimed in claim 1, characterized in that at least one of said first and second mirrors (M1B, M2B, M1C, M2C, M1D, M2D) is
35 linked, via an associated optical coupling means (C1B, C2B, C1C, C2C, C1D, C2D), to two lengths (F1, F2, F3) of said optical fiber (F).
4. The emitter as claimed in claim 3,

characterized in that said optical coupling means (C1B, C2B) comprises two lenses (4 to 7) optically linking said two lengths (F1, F2, F3) of the optical fiber (F), the mirror (M1B, M2B) associated with said optical
5 coupling means (C1B, C2B) being placed between said lenses (4 to 7).

5. The emitter as claimed in claim 3, characterized in that said optical coupling means comprises at least one graded-index lens (8 to 13).

10 6. The emitter as claimed in any one of the preceding claims, characterized in that it comprises means (16) preventing an electromagnetic pulse generated by said generator (2) from returning toward the latter.

15 7. The emitter as claimed in any one of the preceding claims, characterized in that said generator (2) is capable of generating at least two pulses, of different wavelengths.

20 8. A test system for determining the losses of a fiber-optic component, said system comprising:

- an optical source (1D) capable of emitting at least one electromagnetic pulse;
- a photoreceiver (20) capable of measuring characteristics of an electromagnetic pulse
25 emitted by said optical source (1D) and transmitted by a fiber-optic component (19, 21); and
- data acquisition, storage and processing means
30 (22, 24) which receive the measurements generated by said photoreceiver (20) for said fiber-optic component (19) to be tested and for a reference fiber-optic component (21) and which determine, on the basis of these measurements, the losses of
35 said fiber-optic component (19) to be tested, characterized in that said optical source comprises the emitter (1D) specified under any one of claims 1 to 7.

9. The test system as claimed in claim 8,

characterized in that the optical fiber (F) of the emitter (1D) for emitting electromagnetic pulses has at least two characteristics, the core diameter and the numerical aperture, which are predetermined and in that
5 at least one of said characteristics of said optical fiber (F) is identical to that of the fiber-optic component (19) to be tested.

10. The use of the emitter specified under any one of claims 1 to 7, in order to determine the value of at
10 least one characteristic parameter of a fiber-optic component, in which use:

- a) at least one electromagnetic pulse is generated, which is emitted into said fiber-optic component (19);
 - 15 b) measurements relating to said electromagnetic pulse transmitted by said fiber-optic component (19) are carried out; and
 - c) said characteristic parameter is determined at least from said measurements,
- 20 characterized in that, in step a), an electromagnetic pulse train is generated by means of said emitter, at least some of the electromagnetic pulses of which have different values for at least one optical characteristic, and in that, in step c), the value of
25 said characteristic parameter is determined for each of said different electromagnetic pulses of said pulse train.

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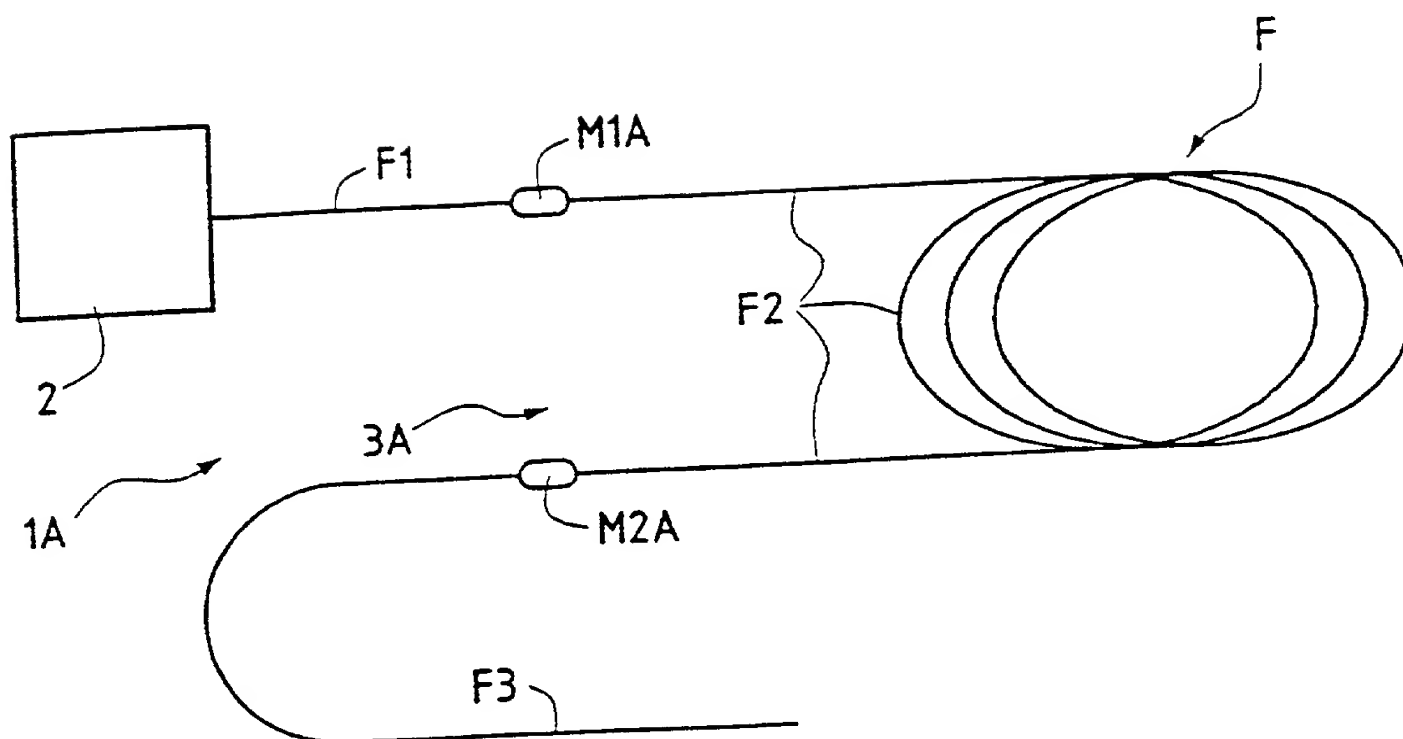


FIG.1

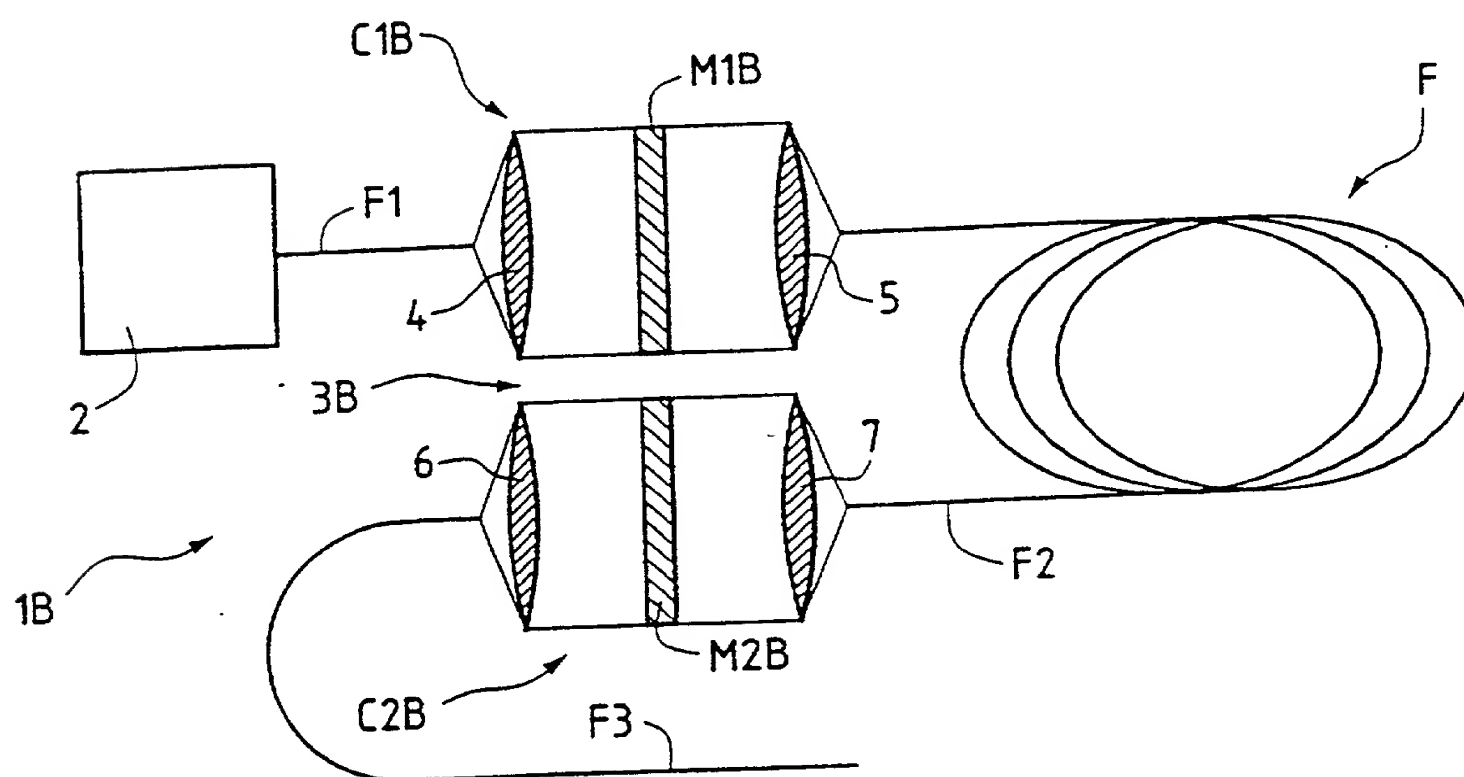


FIG.2

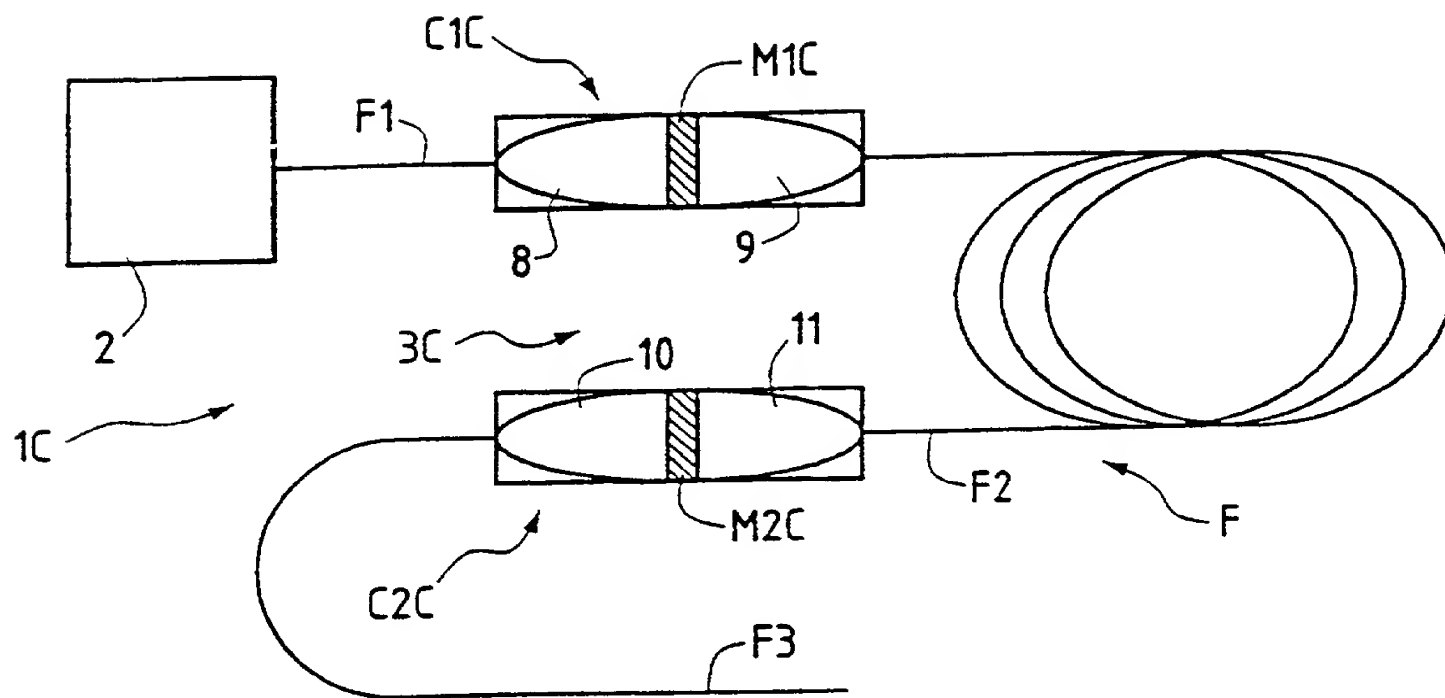


FIG.3

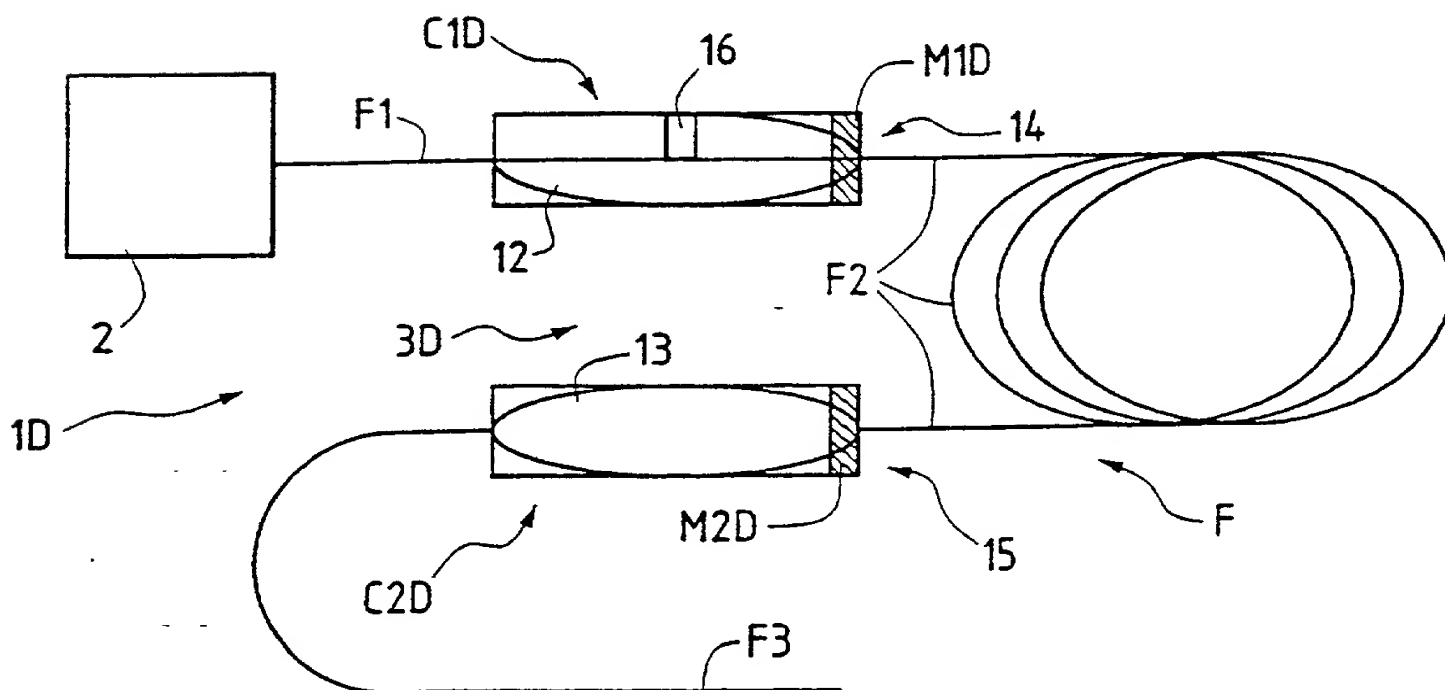


FIG.4

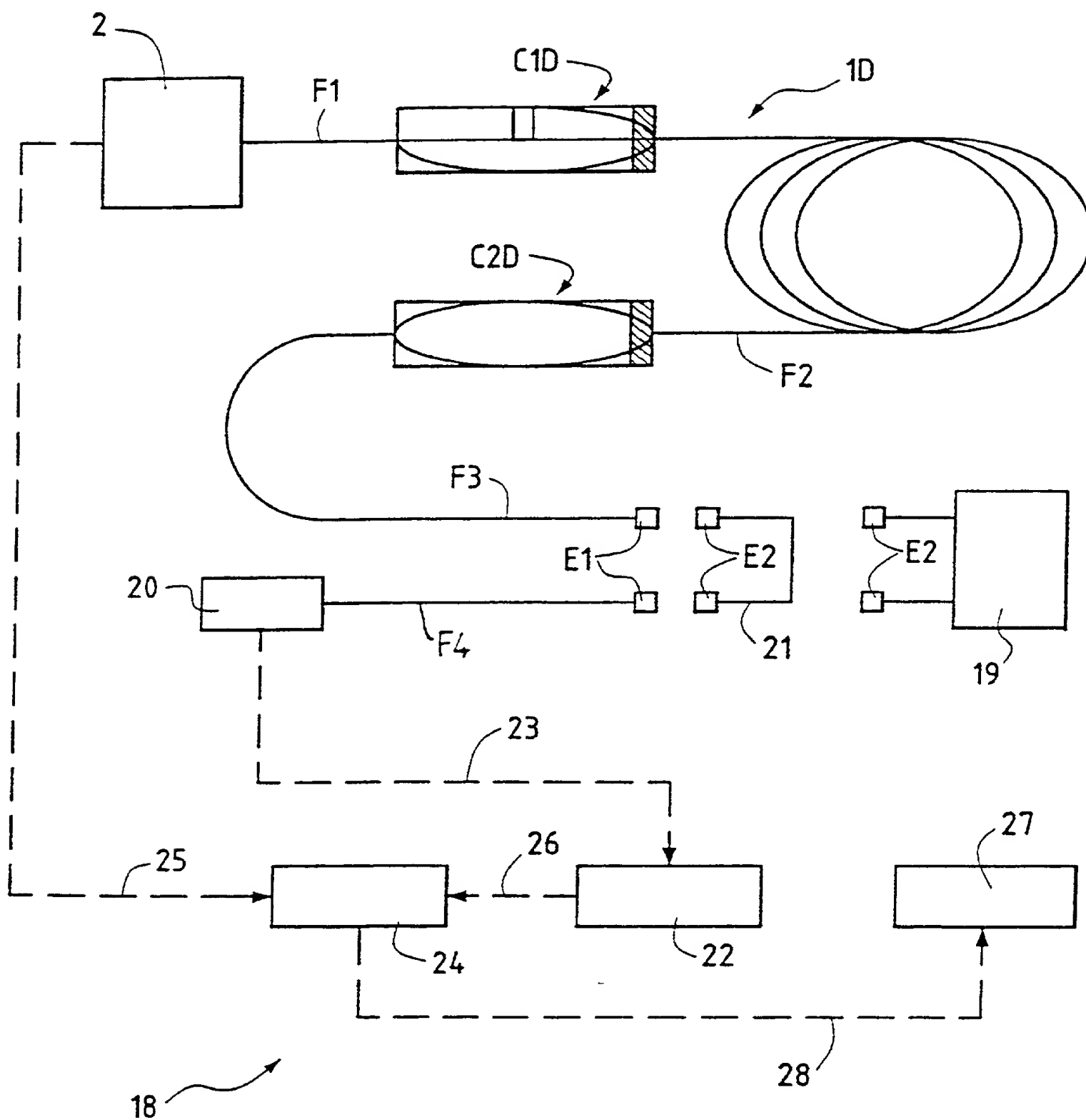


FIG.5

APPLICATION FOR UNITED STATES PATENT

Declaration for Patent Application

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled: 1 Electromagnetic pulse train generation for testing optical fibres.

the specification of which

2 (file no. _____)

(check at least one)

3 ☒

is attached hereto

4 ☐

was filed on _____

as (5) U.S. Application Serial no. _____

6 ☐

and was amended on _____

(if applicable)

Use this portion only if you are entering the U.S. National phase based on a PCT International Application Designating the U.S.

7 ☒

was filed as PCT international application

8

Number PCT/FR99/02400- WO 00/22402

9

on 7 October 1999

10

and was amended under PCT Article(s) 19 and/or 34

on _____

(if applicable).

I hereby declare that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended, by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me which is material to patentability in accordance with Title 37, Code of Federal Regulations, § 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, § 119 or 365 of any foreign application (s) for patent or inventor's certificate listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date earlier than that of the application(s) on which priority is claimed.

Prior (Foreign) Application(s) any Priority Claims Under 35 U.S.C. 119 or 365

FRANCE

98 12601

08 OCTOBER 1998

(Country)

(Number)

(Day/Month/Year Filed)

Priority Claimed

☒

☐

Yes

No

☐

☐

Yes

No

☐

☐

Yes

No

(Country)

(Number)

(Day/Month/Year Filed)

(Country)

(Number)

(Day/Month/Year Filed)

☐ Additional foreign application numbers are listed on a supplemental priority data sheet attached hereto.

Priority Claim(s) from U.S. Provisional Application(s) - I hereby claim the benefit under Title 35, United States Code, § 119(e) of any United States provisional application(s) listed below:

Application No. _____

(Day/Month/Year Filed)

Application No. _____

(Day/Month/Year Filed)

☐ Additional provisional application numbers are listed on a supplemental priority data sheet attached hereto.

Do not use this portion to identify a PCT application if the parent application is the U.S. National phase of the PCT application

I hereby claim the benefit under Title 35, United States Code, 120 of any United States application(s) or under Title 35, United States Code, 365 of any PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code § 112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56 which became available between filing date of the prior application and the national or PCT international filing date of this application.

12

(U.S. Parent Application or PCT Parent Number)

(Parent Filing Date)

Status (patented, pending, abandoned)

☐ Additional U.S. or PCT international application numbers are listed on a supplemental priority data sheet attached hereto.

I hereby appoint the following attorneys of the firm of Stevens, Davis, Miller & Mosher, L.L.P. as my Attorneys of record with full power of substitution and revocation to prosecute this application and to transact all business in the Patent and Trade Mark Office:

James E. Ledbetter, Reg. No. 28732; Thomas P. Pavelko, Reg. No. 31689; and Anthony P; Venturino, Reg. No. 31674.

ALL CORRESPONDENCE IN CONNECTION WITH THIS APPLICATION SHOULD BE SENT TO STEVENS, DAVIS, MILLER & MOSHER, L.L.P., 1615 L. Street, N.W., Suite 850, Washington, D.C. 20036.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 100 1 of Title 18 of the United States Code, and that such willful statements may jeopardize the validity of the application or any patent issuing thereon.

PAGE 2 OF U.S.A. DECLARATION FORM

13a	Typewritten Full Name of Sole or First Inventor	<u>Bruno</u>	<u></u>	<u>DUCHENNE</u>
		Given Name	Middle Name	Family Name
14a	Inventor's Signature	<u>Bruno Duchenne</u>		
15a	Date of Signature	<u>03</u>	<u>09</u>	<u>01</u>
		Month	Day	Year
16a	Residence	<u>31650 SAINT ORENS DE GAMEVILLE - France</u>		
		City	State or Province	Country
17a	Citizenship	<u>French</u>		
18a	Post Office Address (Insert complete mailing Address, including country)	<u>7, Impasse de la Forge - 31650 SAINT ORENS DE GAMEVILLE - France</u>		
13b	Typewritten Full Name of Sole or Second Inventor	<u>Jacques</u>	<u></u>	<u>ISBERT</u>
		Given Name	Middle Name	Family Name
14b	Inventor's Signature	<u>Jacques Isbert</u>		
15b	Date of Signature	<u>03</u>	<u>09</u>	<u>01</u>
		Month	Day	Year
16b	Residence	<u>31100 TOULOUSE - France</u>		
		City	State or Province	Country
17b	Citizenship	<u>French</u>		
18b	Post Office Address (Insert complete mailing Address, including country)	<u>25, Rue Saint Hippolyte - 31100 TOULOUSE - France</u>		
13c	Typewritten Full Name of Sole or Third Inventor	<u></u>	<u></u>	<u></u>
		Given Name	Middle Name	Family Name
14c	Inventor's Signature			
15c	Date of Signature	<u></u>	<u></u>	<u></u>
		Month	Day	Year
16c	Residence			
		City	State or Province	Country
17c	Citizenship			
18c	Post Office Address (Insert complete mailing Address, including country)			
13d	Typewritten Full Name of Sole or Fourth Inventor	<u></u>	<u></u>	<u></u>
		Given Name	Middle Name	Family Name
14d	Inventor's Signature			
15d	Date of Signature	<u></u>	<u></u>	<u></u>
		Month	Day	Year
16d	Residence			
		City	State or Province	Country
17d	Citizenship			
18b	Post Office Address (Insert complete mailing Address, including country)			

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